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Efeito das concentrações de presas e água salinizada no desenvolvimento inicial de *Pyrrhulina brevis* (Steindachner, 1876), um peixe ornamental da Amazônia

Effect of prey concentrations and salinized water on initial development of *Pyrrhulina brevis* (Steindachner, 1876), an Amazonian ornamental fish

Efecto de las concentraciones de presas y agua salina en el desarrollo inicial de *Pyrrhulina brevis* (Steindachner, 1876), un pez ornamental del Amazonas

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Resumo

Objetivou-se com este estudo avaliar o efeito de diferentes concentrações de presas (50; 100; 150 e 200 náuplios de artêmia pós-larva^{-1} dia^{-1}) e água salinizada (0; 1 e 2 g L^{-1}) na larvicultura de *Pyrrhulina brevis*, um peixe ornamental da Amazônia. O experimento foi conduzido em delineamento inteiramente casualizado, em esquema fatorial 4x3, com três repetições. Um total de 360 pós-larvas, foram distribuídas aleatoriamente em 36 aquários (1L), a 10 pós-larvas L^{-1}. Ao final do período experimental (15 dias), as pós-larvas foram medidas, pesadas e contabilizadas. Não foi identificada interação entre as concentrações de presas e a água salinizada para todos os parâmetros avaliados. Os melhores resultados de crescimento, tanto em comprimento quanto em peso, foram observados nas pós-larvas que receberam 150 e 200 náuplios de artêmia pós-larva^{-1} dia^{-1}, enquanto que a menor taxa de sobrevivência foi observada nas pós-larvas alimentadas com 50 e 100 náuplios de artêmia pós-larva^{-1} dia^{-1}. O comprimento final e o ganho de comprimento foram maiores quando as pós-larvas foram criadas em água salinizada a 1 e 2 g L^{-1}, enquanto que o peso final, o ganho de peso e a taxa de crescimento específico foram maiores nas pós-larvas submetidas a 1 g L^{-1} de água salinizada. A uniformidade do lote para peso e comprimento dos peixes não mostrou diferença significativa, independente das concentrações de presas e água salinizada utilizada. Dessa forma, recomenda-se o fornecimento de 150 náuplios de artêmia pós-larva^{-1} dia^{-1} em água salinizada a 1 g L^{-1} durante a primeira alimentação de *Pyrrhulina brevis*.

Palavras-chave: Desempenho produtivo; Ictiofauna da Amazônia; Manejo alimentar; Piscicultura ornamental.

Abstract

The objective of this study was to evaluate the effect of different prey concentrations (50; 100; 150 and 200 artemia nauplii post-larvae^{-1} day^{-1}) and salinized water (0; 1 and 2 g L^{-1}) on larviculture of *Pyrrhulina brevis*, an Amazonian ornamental fish. The experiment was carried out in a completely randomized design, in a 4x3 factorial design, with three replicates. A total of 360 post-larvae were randomly distributed in 36 aquariums (1L), to 10 post-larvae L^{-1}. At the end of the experimental period (15 days) the post-larvae were measured, weighed and

counted. No interaction was identified between the prey concentrations and salinized water for all evaluated parameters. The best growth results, both for length and weight, were observed in the post-larvae that received 150 and 200 artemia nauplii post-larvae^{-1} day^{-1}, while the lower survival rate was observed in post-larvae fed 50 and 100 artemia nauplii post-larvae^{-1} day^{-1}. The final length and length gain were higher when the post-larvae were reared in salinized water at 1 and 2 g L^{-1}, while the final weight, weight gain and specific growth rate were higher in post-larvae submitted to 1 g L^{-1} of salinized water. The uniformity of the batch for weight and length of the fish showed no significant difference, independent of the prey concentrations and salinized water used. Thus, the supply of 150 artemia nauplii post-larvae^{-1} day^{-1} in salinized water at 1 g L^{-1} is recommended during the first fed of *Pyrrhulina brevis*.

Keywords: Growth performance; Amazonian ichthyofauna; Feeding management; Ornamental fish farming.

Resumen

El objetivo de este estudio fue evaluar el efecto de diferentes concentraciones de presas (50; 100; 150 y 200 nauplios de artemia post-larva^{-1} día^{-1}) y agua salina (0; 1 y 2 g L^{-1}) sobre la larvicultura de *Pyrrhulina brevis*, un pez ornamental del Amazonas. El experimento se realizó en un diseño completamente al azar, en un esquema factorial 4x3, con tres repeticiones. Un total de 360 post-larvas se distribuyeron al azar en 36 acuarios (1L), a 10 post-larvas L^{-1}. Al final del período experimental (15 días), se midieron, pesaron y contaron las post-larvas. No se identificó interacción entre las concentraciones de presas y el agua salina para todos los parámetros evaluados. Los mejores resultados de crecimiento, tanto en longitud como en peso, se observaron en las post-larvas que recibieron 150 y 200 nauplios de artemia post-larva^{-1} día^{-1}, mientras que la tasa de supervivencia más baja se observó en las post-larvas alimentadas con 50 y 100 nauplios de artemia post-larva^{-1} día^{-1}. La longitud final y la ganancia de longitud fueron mayores cuando las post-larvas se criaron en agua salina a 1 y 2 g L^{-1}, mientras que el peso final, la ganancia de peso y la tasa de crecimiento específico fueron mayores en la post-larvas sometidas a 1 g L^{-1} de agua salina. La uniformidad del lote para el peso y la longitud de los peces no mostró diferencias significativas, independiente de las concentraciones de presas y agua salina utilizadas. Por lo tanto, se recomienda suministrar 150 nauplios de artemia post-larva^{-1} día^{-1} en agua salina a 1 g L^{-1} durante la primera alimentación de *Pyrrhulina brevis*.

Palabras clave: Rendimiento productivo; Ictofauna amazónica; Gestión de alimentos; Piscicultura ornamental.

1. Introduction

Ornamental fish from Lebiasinidae family are highly appreciated in aquarium trade industry due to their peaceful behavior and exuberant color (Abe et al., 2015; Abe et al., 2019). Within this family, *Pyrrhulina brevis* stands out for being a freshwater fish endemic from the Amazon basin. It presents a cylindrical and elongated body, superior mouth and a shoal habit (Weitzman & Weitzman, 2003). This fish species shows potential in the international market and can be traded for values up to £ 2.48 per adult individual (ePond Shop, 2020). However, despite its attractive characteristics, there are still few studies aiming the development of new management protocols to improve its commercial production, especially on their first life stages (Abe et al., 2015).

In the aquaculture production chain, larviculture can be considered the most important and critical stage (Herath & Atapaththu, 2013), due to the sensitivity of the organisms to pathogenic infections, nutritional management and changes in water parameters (Zuanon et al., 2011; Dias et al., 2016; Abe et al., 2019). In addition to the lack of information of the best management procedures to be adopted (Santos & Luz, 2009). The post-larvae have a digestive system still in development (Portella et al., 2014; Fabregat et al., 2015) and have a great difficulty in assimilating nutrients from inert diets (Pedreira et al., 2008; Diemer et al., 2012), being necessary the use of live organisms to enable an adequate fish growth (Schütz et al., 2008; Fosse et al., 2013).

Artemia nauplii are the live food most utilized in global aquaculture, being commonly used as prey for freshwater fish post-larvae (Jomori et al., 2013). For an adequate development of fish during its initial stage of life, is necessary supplied food in satisfactory quantities (Santos & Luz, 2009). In general, low amounts of live food can directly affect the growth and survival of fish, mainly due to the dispute between individuals (Santos & Luz, 2009; Santos et al., 2015). On the other hand, excessive feeding leads to an increase in production costs and can deteriorate water quality (Lee et al., 2000; Luz & Portella, 2015). Thus, determining the ideal prey concentration is essential to improve feeding management.

The use of sodium chloride (NaCl) in water during the initial phases of freshwater fish culture has been considered a good strategy to promote an optimal development of post-larvae (Santos & Luz, 2009; Jomori et al., 2012). The increase in water salt concentration makes possible the reduction of energy expenditure by fish for osmoregulation (Salaro et al., 2012; Fabregat et al., 2015) and the redirection of this energy to other physiological processes, such as growth or immune responses (Baldisserotto et al., 2007). In addition, the larviculture in

salinized water favors the use of artemia nauplii as live food (Jomori et al., 2013), keeping the microcrustacean alive for a longer time and thus, more attractive for the fish post-larvae (Silva et al., 2019).

Production of Amazonian ornamental fish has become an effective option to protect wild stocks and generate income in Brazil (Abe et al., 2019). *Pyrrhulina brevis* is considered a promising species for Brazilian ornamental fish farming. However, information on feeding management and adequate conditions for this species is still scarce (Abe et al., 2015). Thus, the aim of this study was to evaluate the growth performance, uniformity of the batch and survival rate of *Pyrrhulina brevis* post-larvae submitted to different prey concentrations and salinized water.

2. Methodology

This is a quantitative, experimental and applied research. According to Pereira et al. (2018), the present study has a quantitative approach once it uses a collection of data that are later analyzed by statistical methods to verify the relationships between variables. In this case, the values of growth performance, uniformity of the batch and survival rate of *Pyrrhulina brevis* post-larvae were analyzed and compared using statistical methods. In addition, it is also an experimental field research of applied nature performed at laboratory level (Gerhardt & Silveira, 2009), in which the conditions were adapted to verify the effects of prey concentrations and salinized water in larviculture of *Pyrrhulina brevis*. It aimed to optimize the growth of this species in captivity condition.

2.1. Fish and culture conditions

The experimental trial was conducted at the Laboratory of Ornamental Fish, of the Faculty of Fisheries Engineering, Institute for Coastal Studies, Federal University of Pará, Bragança *Campus*, Pará State, Brazil. A total of 360 *Pyrrhulina brevis* post-larvae, with seven days after hatching and presenting an initial mean weight and length of 1.49 ± 0.31 mg and 4.24 ± 0.25 mm (mean ± SD), respectively, was used. The post-larvae did not have a yolk sac and had an ideal mouth opening for accepting exogenous food. For the initial biometrics, due to the small size and fragility of the fish, a sample of 30 individuals was used to estimate the initial mean weight and length. Subsequently, the fish were randomly distributed into 36

aquariums (1L), at 10 post-larvae L^{-1} and the laboratory was kept under natural photoperiod of approximately 12/12 h light/dark condition.

The experiment was carried out in a completely randomized design, in a 4x3 factorial design, with three replicates. Four prey concentrations (50; 100; 150 and 200 artemia nauplii post-larvae^{-1} day^{-1}) and salinized water at three concentrations (0; 1 and 2 g L^{-1}) were evaluated, for a period of 15 days. The *P. brevis* post-larvae were fed with artemia nauplii four times a day, at 8:00, 12:00, 16:00 and 18:00 h, as recommended by Abe et al. (2015). One hour after the last feeding, all the experimental units were siphoned, being exchanged approximately 30% of the useful volume of each aquarium, for withdrawal of feces and possible food residues. During the cleaning management, the fish were counted to adequacy the prey concentrations in case of mortality.

2.2. Artemia hatching

Artemia nauplii were obtained after incubation of the cysts in salinized water (35 g L^{-1}) for 24 hours with constant aeration and artificial lighting, with the aid of fluorescent lamps (15 W). After hatching, the artemia nauplii were withdrawn by siphoning, washed in running water to remove the salinized water and transferred to a 200 ml container. Then, a 0.5 ml aliquot was collected from the container and the count of the nauplii was performed in order to estimate its density. The counting of the nauplii was performed in triplicate, with the aid of petri dish under stereomicroscope (QUIMIS Q714Z-2) with increase of 40x. After estimating the density of nauplii, the volume to be supplied in each treatment was calculated.

2.3. Water parameters

During the experimental period, the parameters of water quality, temperature (ºC), pH, dissolved oxygen (mg L^{-1}) and electrical conductivity (µS cm^{-1}) were measured daily using a multiparameter appliance (HORIBA U-50). In addition, total ammonia levels (mg L^{-1}) were measured every 3 days, using Kit Labcon Test (Industry and Commerce of Alcon dehydrated foods).

During the 15 days of the experiment, the temperature remained at 26.03 ± 0.10 ºC, the pH at 6.94 ± 0.27, the dissolved oxygen at 6.09 ± 0.21 mg L^{-1}, electrical conductivity at 2.12 ± 1.27 µS cm^{-1} and total ammonia at 0.08 ± 0.03 mg L^{-1}, remaining within the appropriate condition for Amazonian fish farming (Silveira et al., 2009).

2.4. Growth performance, uniformity of the batch and survival rate

At the end of the experimental period, all post-larvae were counted, measured and weighted with the aid of a digital caliper (PANTEC-150; 0.01mm) at an analytical balance (GEHAKA AG200; 0.0001g), respectively. The determined parameters were: Final length (FL); Length gain (LG) LG = final length - initial length; Final weight (FW); Weight gain (WG) WG = final weight - initial weight; Specific growth rate (SGR) SGR = ((ln final weight - ln initial weight)/number of experiment days) *100 (Lugert et al., 2014); Uniformity of the batch for weight (WU) and length (LU) being WU = (number of fish with weight varying ± 20% from the average in each experimental unit/total number of fish per experimental unit) * 100 and LU = (number of fish with length varying ± 20% from the average in each experimental unit/total number of fish per experimental unit) * 100 (Furuya et al., 1998); and Survival rate (SR) SR = (final post-larvae number/initial post-larvae number) * 100.

2.5. Statistical analysis

For confirmation of normality and homogeneity of variances, data were submitted to Lilliefors's and Bartlett's tests, respectively. After assumptions were satisfied, a *two-way* analysis of variance (ANOVA) at 5% significance was performed. If no interaction between prey concentrations and salinized water was detected, *one-way* ANOVA ($P < 0.05$) of single factors was performed. In case of differences, the Tukey test at a probability level of 5% was performed. Statistical analyses were performed using SPSS (SPSS Inc., Chicago, IL, USA).

3. Results

In the present study, no interaction was identified between the prey concentrations and salinized water. Regarding prey concentrations, when 150 and 200 artemia nauplii post-larvae^{-1} day^{-1} were offered, *P. brevis* post-larvae showed the best growth results, both for length and weight. On the other hand, lower survival rate was observed in post-larvae fed 50 and 100 artemia nauplii post-larvae^{-1} day^{-1}. The uniformity of the batch for weight and length of fish showed no significant difference, independent of the prey concentrations used (Table 1).

Table 1. Growth performance, uniformity of the batch and survival rates (mean ± SD) of *Pyrrhulina brevis* post-larvae fed with artemia nauplii at different prey concentrations.

Performance indices	Prey concentrations (artemia nauplii post-larvae^{-1} day^{-1})				
	50	100	150	200	P value
FL (mm)	8.96±0.2c	10.16±0.3b	10.43±0.3ab	10.71±0.2a	0.00023
LG (mm)	4.87±0.2c	6.07±0.3b	6.34±0.3ab	6.62±0.2a	0.00023
FW (mg)	4.65±0.4c	6.90±0.6b	7.97±0.7a	8.17±0.3a	0.00011
WG (mg)	3.23±0.4c	5.48±0.6b	6.55±0.7a	6.75±0.3a	0.00011
SGR (%.day^{-1})	7.87±0.6c	10.51±0.6b	11.46±0.6a	11.66±0.2a	0.00003
WU (%)	53.33±12.8	49.14±14.3	55.68±12.0	62.22±9.6	0.43455
LU (%)	95.31±7.3	100.00±0.0	98.89±2.0	100.00±0.0	0.21297
SR (%)	92.22±5.2b	95.56±4.9b	97.78±3.5a	97.78±3.5a	0.02498

FL Final length; LG Length gain; FW Final weight; WG Weight gain; SGR Specific growth rate; WU Weight uniformity; LU Length uniformity; SR Survival rate. P value determined by Analysis of Variance (ANOVA). Mean values in the same line, with different letters, are significantly different by Tukey test at 5% probability (n=9). Source: Own study.

In the Table 1, it can be observed that the prey concentrations influenced the growth of the fishes, both for length and weight, showing best results when the highest prey concentrations were provided. In addition, was also observed that the survival rate of fish was impaired in animals that received the lowest prey concentrations.

The final length and length gain were higher when the *P. brevis* post-larvae were reared in salinized water at 1 and 2 g L^{-1}, compared to fish submitted to freshwater. The final weight, weight gain and specific growth rate were higher in post-larvae submitted to 1 g L^{-1} of salinized water, when compared to fish reared in freshwater and 2 g L^{-1} of salinized water. The uniformity of the batch, for weight and length, and the survival rate of fish showed no significant difference, independent of the salinized water used (Table 2).

Table 2. Growth performance, uniformity of the batch and survival rates (mean ± SD) of *Pyrrhulina brevis* post-larvae submitted to different salinized water.

Performance indices	Salinized water (g L^{-1})			
	0	1	2	P value
FL (mm)	9.80±0.6b	10.27±0.6a	10.13±0.5a	0.00053
LG (mm)	5.71±0.6b	6.18±0.6a	6.04±0.5a	0.00053
FW (mg)	6.50±1.3b	7.42±1.2a	6.85±1.3b	0.00267
WG (mg)	5.08±1.3b	6.00±1.2a	5.43±1.3b	0.00267
SGR (%.day^{-1})	9.93±1.5b	10.88±1.2a	10.32±1.3b	0.00108
WU (%)	53.61±15.6	61.76±10.8	49.91±10.9	0.24434
LU (%)	98.33±3.1	98.15±3.4	99.17±1.5	0.32743
SR (%)	96.67±4.4	95.83±5.6	95.00±5.0	0.39340

FL Final length; LG Length gain; FW Final weight; WG Weight gain; SGR Specific growth rate; WU Weight uniformity; LU Length uniformity; SR Survival rate. P value determined by Analysis of Variance (ANOVA). Mean values in the same line, with different letters, are significantly different by Tukey test at 5% probability (n=12). Source: Own study.

In the Table 2, it can be observed that the salinization of the rearing water influenced the fish growth for length and weight, and the use of salinized water in the concentration of 1 g L^{-1}, enabled better results for these variables. In addition, the survival rate of fish showed no significant difference, independent of the salinized water used.

It is noteworthy that both for growth and survival of the fish are essential for the success of ornamental aquaculture, since the fish are sold per unit and the adequate fish growth facilitates their commercialization in the ornamental market.

4. Discussion

Optimal feeding management should be determined to improve feed utilization by the fish and to reduce production costs (Abe et al., 2016). The prey concentration provided during the larviculture period directly influences the development of the fish (Santos & Luz, 2009; Jomori et al., 2013). In the present study, *P. brevis* post-larvae fed 150 and 200 artemia nauplii post-$larvae^{-1}$ day^{-1} showed the best growth values. In this matter, the prey concentration of 250 artemia nauplii post-$larvae^{-1}$ day^{-1} resulted in better growth values for *Heros severus* post-larvae (Abe et al., 2016). Also, for *Lophiosilurus alexandri* post-larvae, 1600 artemia nauplii post-$larvae^{-1}$ day^{-1} showed the best values of growth performance, when

compared to post-larvae that received prey concentration of 100 to 1300 artemia nauplii post-larvae^{-1} day^{-1} (Santos et al., 2015).

On the other hand, the growth of *Astronotus ocellatus* and *Leporinus macrocephalus* post-larvae fed with artemia nauplii was not affected by the different prey concentrations when reared in freshwater (Jomori et al., 2013). *Nannostomus beckfordi* post-larvae fed 100 to 200 artemia nauplii post-larvae^{-1} day^{-1}, also showed no significant difference in growth parameters, independent of the prey concentrations used (Abe et al., 2019). The different results found demonstrate that the ideal prey concentration is a species-specific characteristic and should be determined according to the stage of development of each fish species, in order to optimize the use of the food and rationalize production costs (Abe et al., 2016).

Low prey concentrations can cause increased competition in the group, in addition to increasing the energy cost of post-larvae to capture food (Abe et al., 2015; Santos et al., 2015). On the other hand, high prey concentrations can reduce the utilization of the food provided, increase the production costs and impair water quality (Lee et al., 2000; Luz & Portella, 2015). The supply of 150 artemia nauplii post-larvae^{-1} day^{-1} divided into four daily feeds was satisfactory and reduced the waste of live food in the aquarium of *P. brevis* post-larvae maintained in freshwater (Abe et al., 2015).

Higher survival rate were observed by *P. brevis* post-larvae fed the highest prey concentrations, 150 and 200 artemia nauplii post-larvae^{-1} day^{-1}. The movement and distribution of the artemia nauplii in the water column make this food very attractive to post-larvae (Diemer et al., 2010), improving consumption and consequently the survival rate. *Heros severus* post-larvae fed with 250 artemia nauplii post-larvae^{-1} day^{-1} showed a higher survival rate when compared to post-larvae that received 200, 150 and 100 artemia nauplii post-larvae^{-1} day^{-1} (Abe et al., 2016). In another study with *Heros severus* post-larvae fed with 50, 100 and 150 artemia nauplii post-larvae^{-1} day^{-1}, there was no change in the fish survival rate, independent of the prey concentrations used (Campelo et al., 2019).

The use of salinized water during the initial phases of freshwater fish culture has been considered a good strategy to promote the development of post-larvae (Santos & Luz, 2009; Jomori et al., 2012). The *P. brevis* post-larvae submitted to salinized water at 1 and 2 g L^{-1} showed better results for final length and length gain. These results may be related to the reduction of the osmotic gradient between farmed water and fish plasma, which reduce the fish energy expenditure for osmoregulation (Salaro et al., 2012; Fabregat et al., 2015). Energy that can be redirected to other physiological processes, such as growth and immune responses (Baldisserotto et al., 2007).

The used of artemia nauplii as live food may also be the reason for the best growth performance results found. Artemia are marine microcrustaceans that have low survival rates in freshwater, which leads to reduced feed efficiency of post-larvae and impairs their normal growth (Beux & Zaniboni-Filho, 2006; Luz & Santos, 2008; Santos et al., 2015). In this context, the salinized water can help to increase the survival of artemia nauplii, making it available and attractive to the fish post-larvae for longer (Jomori et al., 2013; Coraspe-Amaral et al., 2017; Nascimento et al., 2019).

The *P. brevis* post-larvae submitted to salinized water at 1 g L^{-1} showed better results for final weight, weight gain and specific growth rate. The use of salt in the initial farmed water of freshwater fish can have positive or negative implications, with tolerance to salinized water being recognized as species-dependent (Salaro et al., 2012; Jomori et al., 2013). In the present study, when the salinized water increased from 1 to 2 g L^{-1}, there was a reduction in the weight performance of fish. High concentrations of salt in the initial farmed water of freshwater fish can compromise animal welfare and generate physiological and behavioral changes. Changes that may be related to the osmoregulatory imbalance, caused when the salinized water concentration exceeds the limits of the fish homeostasis control (Luz & Santos, 2008; Dias et al., 2016).

In a review of the effect of salinized water on fish growth, Boeuf and Payan (2001) reported that most of the times the fish species show better growth when reared in intermediate salinity in relation to natural conditions. Jomori et al. (2013), determined that slightly salinized water, at a concentration of 2 g L^{-1}, positively favored the growth of post-larvae of *Colossoma macropomum*, *Brycon amazonicus*, *Astronotus ocellatus* and *Leporinus macrocephalus*, similar results to that found for *P. brevis* post-larvae. The use of slightly salinized water at a concentration of 2 g L^{-1} also provided better growth results for post-larvae of *Piaractus mesopotamicus* (Jomori et al., 2012), *Betta splendens* (Dias et al., 2016) and *Arapaima gigas* (Silva et al., 2019) fed with artemia nauplii.

On the other hand, the increase in salinized water reduced the parameters of growth performance of post-larvae of *Lophiosilurus alexandri* (Luz & Santos, 2008), *Oreochromis niloticus* (Luz et al., 2013) and *Brycon vonoi* (Coraspe-Amaral et al., 2017) when concentrations greater than 2 g L^{-1} were used. For *Colossoma macropomum* post-larvae, 6 g L^{-1} of salt in the initial farmed water led to a reduction in the weight of the animals, whereas for *Brycon amazonicus* and *Astronotus ocellatus* post-larvae, salinized water at 4 g L^{-1} was sufficient to reduce the growth parameters (Jomori et al., 2013). Abe et al. (2015), working with the same species as the present study, recommended the salinized water at 2 g L^{-1} in the

initial farmed water, however the authors did not evaluate lower salinities. In the present study, the salinized water at 1 g L^{-1} was ideal for the larviculture of this species, promoting the best results of growth performance.

The *P. brevis* post-larvae showed no significant difference in survival rate, independent of the salinized water. Experiments with post-larvae of *P. brevis* (Abe et al., 2015) and *Betta splendens* (Dias et al., 2016), reported negative effects on the survival rate of fish with the salinized water increase of 2 to 4 g L^{-1}. This being a characteristic response in freshwater fish (Luz et al., 2013), which may occur due to the osmoregulatory imbalance caused by high salinized water concentrations (Dias et al., 2016). In experiments with post-larvae of *Rhinelepis aspera* (Luz & Santos, 2010), *Piaractus mesopotamicus* (Jomori et al., 2012) and *Oreochromis niloticus* (Luz et al., 2013) survival rate was similar when using freshwater or slightly salinized with 2 g L^{-1} of salt.

The uniformity of the batch, for both length and weight, allows greater ease of management, since fewer classifications will be necessary to keep the animals in homogeneous size. In addition, homogeneous fish are preferred for commercialization, especially in the ornamental fish market, where batch homogeneity is highly valued (Dias et al., 2016; Veras et al., 2016). In the present study, no significant difference was observed for fish weight and length uniformity, independent of the prey concentrations or salinized water used. Similar results were found for post-larvae of *Heros severus* and *Nannostomus beckfordi*, fed with prey concentrations of 100 to 300 and 100 to 200 artemia nauplii post-larvae^{-1} day^{-1}, respectively (Abe et al., 2016; Abe et al., 2019).

The use of salinized water in *Pyrrhulina brevis* larviculture positively favored the post-larvae growth, probably for contribute to the longer survival time of the artemia nauplii and reduce the osmotic stress of the fish, optimizing the energy available for growth. However, the salinized water must be carefully adjusted and monitored, thus it does not exceed the limits of tolerance and impair the fish growth and survival. In addition, the prey concentrations is an important aspect, especially when related to salinity, as it allows to ensure adequate growth and enable the reduction of food waste and production costs.

5. Conclusion and Suggestions

The use of different prey concentrations and salinized water significantly interferes in the growth performance and survival rate of *Pyrrhulina brevis* post-larvae. The supply of 150 artemia nauplii post-larvae^{-1} day^{-1} in salinized water at 1 g L^{-1} is recommended during the

initial culture of this species. The use of slightly salinized water can be an effective strategy to allow better feed efficiency in *P. brevis* larviculture.

The present study presented the functionality of salinized water in *P. brevis* larviculture. However, further studies are still needed to correlating the salinized water with other production managements, such as feeding frequency, stocking density and weaning. Enabling the development of new technological information for rearing post-larvae of this species in captivity.

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Conflicts of interest

The authors declare that they have no conflict of interest.

Ethics approval

The animal procedure and protocol was approved by the Ethics Committee on the Use of Animals of the Federal University of Pará, CEUA/UFPA (Approval number: 7656100517).

Authors' contributions

All authors have contributed significantly and are in agreement with the content of the manuscript.

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